THE SIDEREAL MESSENGER.

CONDUCTED BY WM. W. PAYNE,

DIRECTOR OF CARLETON COLLEGE OBSERVATORY.

JUNE, 1889.

Thou, Lord, in the beginning hast laid the foundation of the earth, and the heavens are the works of thine hands.

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THE SIDEREAL MESSENGER,

CONDUCTED BY WM. W. PAYNE

DIRECTOR OF CARLETON COLLEGE OBSERVATORY, NORTHFIELD, MINN.

VOL. 8, No. 6. JUNE, 1889. WHOLE No. 76.

THE WAVE LENGTH OF LIGHT AS A PRACTICABLE AND A FEASIBLE STANDARD OF LENGTH.

PROFESSORS A. A. MICHAELSON AND E. W. MORLEY.

For THE MESSENGER.

Our experiments have now shown that our method of making the wave length of light of some definite refrangibility a practical standard of length is perfectly feasible. Several steps are involved.

I. We prepare a metallic bar carrying two parallel plane mirrors, whose distance is as great as that at which we can get well defined interference between two pencils of light. We have found that this distance is certainly as much as an eighth of a metre and may be a quarter of a metre.

II. The distance between the two planes is determined in terms of the yard or metre. Our apparatus for this comparison may be called the Interferential Comparer. We have not yet used it for the final comparisons required in our method, but we have had it in daily use for subsidiary comparisons, and have just confidence in the feasibility of making determinations of great accuracy.

III. The whole number of wave lengths, say of sodium light, contained in the distance between the two planes of our intermediate standard (I) is determined. On a standard called E, we have repeated this determination by entirely different steps, and by different observers; the results were 26502, 26502, 26502. The method by which we make this determination by measurements of fractions, with no enumeration of whole numbers may be briefly described. We prepare a set of intermediate standards whose lengths are nearly as the numbers 1, 2, 4, 8, 16, etc. We compare (16) with the metre, (8) with (16), (4) with (8), etc. It is easy to get the length of each within one-fifth of a wave length. For instance, $(1) = 0.4891mm \pm 0.0001mm$. Now

the determinations by other methods of the wave length of D, show that in double this length, the number of waves is $1659.1 \pm .2$ ($\lambda = 5896.08$). We measured this fraction directly, in the refractometer previously described by us: it was .01 instead of .10; the corrected number is therefore 1659.01. With this corrected value, we found double (2) to contain 3314.22 wave-lengths; and correcting the fraction, 3314.27. In this way we have gone in triplicate, with five different kinds of light, to numbers ranging (for these different kinds of light, but for the same intermediate standard between 23270 and 35815; and in duplicate to numbers four times as large for four kinds of light.

IV. The measurement of fractions mentioned above may be made in various ways. We have often made it consist in measuring the diameter of circular interference fringes by means of the filar micrometer. In this way it is not difficult to make determinations trustworthy to $\frac{1}{50}\lambda$, as far as *optical* errors are concerned. Sometimes we make it consist in shortening the effective path of one of the interfering rays by a minute of angular motion of a certain part of the apparatus, and measuring this motion by the torsional couple required to produce it. This method we find capable of almost incredible precision.

V. As a somewhat tangible evidence of the feasibility of our method, we may use our data for the inverse problem of determining wave lengths. The results of two entirely independent series of determinations by one of us, and of one by the other, are as follows:

	Na.	Li.	Hg_y	Hg_g	Hg_v
I	5896.08	6707.98	5790.70	5460.85	4358.42
II	5896.08	6708.00	5790.67	5460.85	4358.42
III	5896.09	6708.00	5790.68	5460.85	4358.41
Mean	5896.083	6707.993	5790.683	5460.850	4358.417

VI. We feel a reasonable confidence that the number of wave lengths in (16) is known to one part in a million as a result of our early experience with apparatus devised in a tentative way. We feel a reasonable confidence that this distance may be made eight-fold or sixteen-fold longer, with a proportionate increase in precision. We think we have the right to hope that, with better apparatus, and with the benefit of the experience already gained, the work of estab-

lishing a material standard a metre in length whose length in wave lengths is known to a millionth or even a ten-millionth may be effected with ease and certainty.

In regard to the relative motion of the earth and the luminiferous ether, I have only to say that the observations of July were repeated in November and December, with the result that if any relative motion between the earth and the luminiferous ether can be detected by such experiments, its amount is less than one-sixth of the absolute motion of the earth.

Cleveland, May 13, 1889.

A NOTE ON DOUBLE-STARS.

W. H. S. MONCK, DUBLIN, IRELAND.

For THE MESSENGER.

That the great majority of double-stars are physically connected, although their motions may be so slow as to have escaped detection up to the present, seems certain. Not only are these stars as a rule closer together than the doctrine of chances will account for, but they exhibit peculiarities which, in the case of casual connection, would be wholly inexplicable. Thus it has been noticed that no blue or green star of decided tint has been found save in immediate connection with a brighter star of a different color; while even when the colors of the component pair are identical another peculiarity is observable, viz., that they are almost equally bright, the brightness being usually very different when the colors are so. Why physical connection leads to these peculiarities is indeed unknown, but that they should have been produced by mere casual arrangement appears incredible. Common proper motion also frequently reveals the existence of physical connection. A few chance coincidences in direction between stars situated at very different distances from us no doubt occur, but if we ascribe one-tenth of the known double-stars to chance coincidence, we shall probably have made a very liberal allowance, while the total number of double-stars now known probably exceeds 10,000. How many more of the known stars are

really double is a matter for further conjecture. The motions of Procyon are strongly suggestive of a companion not yet discovered, as those of Sirius were before the satellite was detected. The class of variable stars known as the Algol-type probably possess satellites which intercept a considerable part of their light at each transit. It would be difficult to name a star with a decided measurable parallax which is known to be single; and as any double-star would appear single if removed to a sufficient distance, the apparent singleness of a very distant star affords no argument against its duplicity. It is, at all events, possible that double-stars may prove to be the rule and single stars the exception.

It is somewhat singular that neither the brightness nor the elements of a double-star afford any direct indication of its distance from us. For let us replace any pair by another pair situated precisely in the same direction at $\frac{1}{n}$ of the distance from us, with masses equal to $\frac{1}{n^3}$ of those of the stars which they replace. The angular distance being the same as before, the true distance of this pair will be $\frac{1}{n}$ of that of the former, and the periodic time will be unaltered. Moreover, assuming the new stars to be of the same density as the old ones, and the surfaces to be equally bright, each star will have the same magnitude as before, the illuminated surface being $\frac{1}{n^2}$ of the former, while the light of each unit of surface will be multiplied by n^2, owing to the nearer distance. The ordinary mode of measuring the distances and angles would fail to afford any distinction between the old and new binary systems, and we may in fact replace any given binary system by an equivalent system at any distance, so long as no attempt is made to determine the parallax (assuming also that no light is lost in transmission.)

It is owing to this property of binary systems that we can compare what I may term the intrinsic brilliancy of any two systems whose orbits are known. Suppose, for instance, that we desire to compare the intrinsic brilliancy of Sirius (and satellite) with that of γ Leonis. According to the *Harvard Photometry* the difference in magnitude is 3.61 (the Oxford measurements make it less), whence it readily appears that the light of Sirius is 27.68 times as intense as that of γ Leonis. Replace γ Leonis by an equivalent pair at

the distance of Sirius. Now, according to Mr. Mann (SIDEREAL MESSENGER for January, 1888, the semi-axis major of the Sirian ellipse is 21″.8, and the period 51.22 years, while Doberck gives for the semi-axis major of the Leonid ellipse 1″.98, and for the period 407.4 years. The relative masses of Sirius and the pair equivalent to γ Leonis are therefore as $\frac{(21.8)^3}{(51.22)^2}$ to $\frac{(1.98)^3}{(407.4)^2}$, or about 84436 to 1. The excess of mass is thus 3000 times as great as that of light, and assuming the density to be equal, the extent of illuminated surface will be proportional to the masses raised to the power $\frac{2}{3}$, or, in this case, 1925 to 1. The unit of surface is therefore, on this supposition, 66 times as bright for γ Leonis as for Sirius. The only way of avoiding this conclusion appears to be to assume that γ Leonis is composed of much lighter materials than Sirius. Sirius, however (as might be expected from its color), stands by no means lowest in the scale of brightness, though γ Leonis apparently stands highest. I wished to indicate the general mode of comparison, and also to give an estimate for these two remarkable binaries on the latest available data. The brilliancy of Sirius is, of course, lessened in this mode of comparison by the faintness of its satellite, whose surface is perhaps half as large as that of the primary; but neglecting the light of the satellite altogether, γ Leonis appears to be brighter (for each unit of surface) than Sirius in the ratio of 44 to 1. (I confess, however, that I think Mr. Mann's value of the semi-axis major of the Sirian orbit is too large.)

There is good reason, I think, for believing that the parallaxes of the great majority of double-stars are very small. In a larger proportion of cases there is scarcely any perceptible difference, either in the position or the distance, for a considerable number of years, notwithstanding which the distance (in angular measure) is not very great. A first approximation may be made in such cases by supposing the orbit to be circular. Most probably it is not so, but if the period is less than that computed on the assumption of a circular orbit the mean distance will also be less, and if the period is greater the mean distance will be greater. As regards mass and parallax therefore the necessary connections (which will no doubt be made hereafter) tend to neutralize each other, while the substitution of the true for the appar-

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ent orbit will in all cases increase the distance and thus reduce the mass and parallax computed on the assumption of a circular orbit whose plane is at right angles to the line of sight. I take a few examples to illustrate the consequences of this assumption. The first is the star 6 Cygni, for which Sir Robert Ball found a parallax of 0″.482, while Professor Asaph Hall obtained a negative parallax with the same comparison star. According to the measures in Crossley, Gledhill and Wilson's *Handbook of Double-Stars* the angular distance has remained nearly constant at about 10″ for over forty years. During this period the angle described is 4°.3, which a critical examination seems more likely to reduce than to increase (I have no recent measurements of this interesting pair at hand). A period of 3,600 years with a mean angular distance of 10″ is thus indicated. The equivalent parallax (as I termed it in my former article, or hypothetical parallax, if the phrase be preferred) for such an orbit is 0″.042. If Sir Robert Ball's parallax is correct the mass of this binary pair probably does not exceed that of Jupiter. It is possible, however, that while Ball's parallax is too large Hall's is too small. With a parallax of 0″.042 the proper motion of the star in declination alone exceeds 15 radii of the earth's orbit in the year. It may be worth while before leaving this star to compare its brilliancy with that of γ Leonis. An equivalent pair to γ Leonis, placed at the distance of 6 Cygni, would contain only about ⅔ of the mass (on the above assumption as to the orbit of 6 Cygni) of the latter star; but the difference in magnitude being about 3.8, γ Leonis gives at least 33 times as much light. The contrast is almost as striking as in the case of Sirius.

I have referred to 6 Cygni chiefly as an interesting star, for there are comparatively few double-stars situated at a distance of 10″ whose angular motion can be detected at all. As a type of another class in which angular motion can be detected I take the first star in the *Handbook*, Σ 3063. Observation indicates a period of at least 1,400 years with a mean distance of 1″.8 (which has hardly altered for half a century). The equivalent (or hypothetical) parallax here is only 0″.015. In 69 Andromedæ the distance is only about 5″, and yet 40 years have produced no perceptible change in the angle. If we allow a motion of 1° in 40 years (and it

may be much less than this), we should obtain a period of over 14,000 years for revolution in a circular orbit and an equivalent parallax of less than the hundredth part of a second. But in Σ 59 the angular motion appears to be equally slow, while the angular distance is little more than 2″, thus suggesting a still smaller parallax. One of the best known double-stars is Mizar, in the Great Bear. It is doubtful whether any angular motion has been observed since its duplicity was first detected, much more than a century since. The distance of the components is indeed considerable, but still the equivalent parallax must be very small. On the assumption of circular orbits, the equivalent parallaxes for the pair ε_1 ε_2 Lyræ are about 0″.020 and 0″.026 respectively. As their distances from us are probably nearly equal it may be conjectured that the mass of ε_1 is somewhat greater than that of ε_2. For the Pole star the measures are uncertain, but on the assumption of a circular orbit the equivalent parallax seems to agree fairly with the most recent determinations of its actual parallax. In these latter instances, however, the binary stars are probably nearer to us than the average of the class to which they belong. 69 Andromedæ and Σ 59 are more typical cases. Of the binary stars whose orbits are still undetermined, it seems likely that not one in ten has a parallax of 0″.01. Accurate results, however, cannot be expected for some time to come.

THE STUDY OF VARIABLE STARS.

During the last four years Harvard College Observatory has given particular attention to the study of variable stars, and from time to time several articles have been published by different astronomers connected with the Observatory, giving information as to methods for the proper study of such stars, observations of old and new variable stars, and, to some extent, setting forth what other astronomers were doing in this comparatively new branch of astronomical observation.

Very recently Professor E. C. Pickering, the Director of the Observatory, has published another important and most use-

ful paper on this theme, under the title of "Index to Observations of Variable Stars." This publication is intended to be a systematic arrangement of observations of variable stars, as far as known, covering the entire period from 1840 to the end of 1887. These observations have been reported to Harvard College Observatory chiefly by the astronomers who made them, and are mostly new. Three large series of unpublished observations by Argelander, Heis, and Schmidt, however, are given in the account of the separate series, and they are important because of their early date and the reputation of the observers.

This publication also contains a notice of some others, especially of those found in the three most familiar published series of observations of variable stars: Argelander's comparisons in Vol. VII of the Bonn observations, those of Schönfeld, and those of Oudemans.

A deservedly prominent place in this account is given to the work of Mr. S. C. Chandler, who is author of a catalogue of variable stars which was published in Nos. 179 and 180 of the *Astronomical Journal.*

The following statement taken from this paper will be of interest to those who would care to know the names of observers, the instruments, and something of the method of observations:

The observations of Argelander, in the second part of Vol. VII of the Bonn observations, and also many yet unpublished, a copy of which has been made with the kind permission of Professor Schönfeld were chiefly made with the naked eye or with an opera-glass; telescopes were employed only in special cases. The method of numerical comparison, by means of grades or steps, between the amounts of light received from different stars, which was introduced by Argelander, has been extensively employed by subsequent observers.

Mr. T. W. Backhouse, of Sunderland, England. A refracting telescope by Cooke, aperture 4¼ inches, magnifying powers 38 and 75, was often used; other observations were made with the finder, power 9, and the rest with a field-glass and similar instruments of low power, or with the naked eye. The methods of comparison were chiefly three, —that of Argelander; that in which the relative brightness

of the star observed is indicated by a fraction of the apparent difference between two comparison stars; and that of verbal description, in which, however, the words employed are regarded as having numerical values.

Mr. Joseph Baxendell, of Birkdale, Southport, England. The telescope used in the observations was an achromatic refractor by Cooke, aperture 6 inches; the magnitudes of the variables were determined by comparisons with neighboring stars whose magnitudes had been determined by the method of limiting apertures.

Mr. Joseph Baxendell, Jr. The place, instrument, and method of observation were the same as described above.

National Observatory at Cordoba, in the Argentine Republic, the Director of which, Professor John M. Thome, has kindly communicated the facts here given. The observers at Cordoba were Messrs. F. H. Bigelow, W. M. Davis, J. T. Hedrick, Miles Rock, and J. M. Thome.

Mr. S. C. Chandler made observations in 1883 and 1884 at this Observatory with a telescope by Clacey, aperture 6¼ inches, magnifying power generally 45, sometimes 125 or 200. The method of observation was that of Argelander.

Dr. N. C. Dunér, of the Observatory of Lund, Sweden. The observations were made by the method of Argelander.

Mr. John H. Eadie; observations were made at Bayonne or at Madison, both in New Jersey, by the method of Argelander. The telescope employed was made by John Byrne; its aperture was 3¼ inches, and the lowest magnifying power was about 50. Mr. Eadie acted in co-operation with Mr. Parkhurst in a manner explained below. This system of co-operation appears to be highly efficient and economical. It deserves extension and general introduction among observers not too far separated for ready communication with one another.

Rev. T. E. Espin, of Wolsingham, Darlington, England. The instruments employed were a binocular glass and reflecting telescopes of 9 and 17¼ inches in aperture, the last by Calver. Mr. Espin's Observatory has recently been removed to Tow Law, near Darlington.

Large equatorial telescope of Harvard College Observatory. The aperture and focal length of the instrument are respectively 15 and 279 inches. The magnifying power employed

was ordinarily 103. The observers were Messrs. Arthur Searle and O. C. Wendell. The observations to which reference is made were mainly photometric determinations, made with the wedge photometer, of the brightness of the comparison stars known to have been employed by previous observers; but when the variable stars themselves were visible, they were incidentally compared with others by estimate, according to the method of Argelander, and were also observed with the wedge. This work is to be continued; and it is desired to make it include as many as possible of the comparison stars which have been employed by any observer. The list now in use is chiefly derived from the published work of Argelander, Schönfeld, and Oudemans. Observers are requested to send lists of the comparison stars not included in these publications, which they have themselves employed, or which have been employed to their knowledge by others. It is very desirable that not only the places of these stars, but also their designations in the Durchmusterung, when they occur in that Catalogue, should be entered in the lists thus sent.

Mr. J. E. Gore, of Ballysodare, Ireland. The instrument was a binocular field-glass having object-glasses of 2 inches aperture, and a magnifying power of about 6 diameters. The method of Argelander was employed.

Dr. E. Hartwig, whose observations were made at Dorpat, Russia.

Rev. J. G. Hagen, S. J., of the College of the Sacred Heart, Prairie du Chien, Wisconsin, now of Washington, D. C. The instrument was a telescope by Merz, aperture 3 inches. The observations were made by the division into tenths of the interval between two comparison stars, and subsequently by the method of Argelander. Messrs. Zwack and Zaiser took part in the work as assistants.

Dr. E. Heis, of Münster, Germany. Father Hagen, having received from the family of Dr. Heis a series of note-books containing records of his observations, has kindly forwarded them to this Observatory for examination. It has thus become practicable to include in the present publication an enumeration of the observations of variable stars made by Dr. Heis.

Mr. George Knott, of Knowles Lodge, Cuckfield, Hay-

ward's Heath, England. The telescope was by Clark, aperture 7⅓ inches, with a finder, aperture 2 inches. The variable was compared with stars differing little from it in brightness; the magnitude of the comparison stars, and sometimes the magnitude of the variable, were determined by the method of limiting apertures.

Mr. H. A. Lawrance, whose observations will be mentioned below in connection with those by Professor W. Upton.

Major E. E. Markwick, of Haulbowline, Queenstown, Ireland.

The meridian photometer of Harvard College Observatory. The observers using this instrument were Messrs. E. C. Pickering and O. C. Wendell. The magnitudes of the stars observed with it were referred to a series of one hundred circumpolar stars, the brightness of which was determined by observations described in Vol. XIV of the Annals of the Observatory.

Mr. C. E. Peek, of the Rousdon Observatory, Devon, England.

Mr. J. Plassmann, of Warendorf, Germany, who has kindly furnished some observations recently made by him with small instruments.

Mr. Henry M. Parkhurst, of Brooklyn, N. Y. The instrument was a telescope by Fitz, aperture 9 inches, and magnifying powers 56, 90, and 150. Many of the observations were made by the method of Argelander, others by photometric apparatus devised by Mr. Parkhurst, and described in his account of observations of asteroids. The system of co-operation between him and Mr. Eadie has already been mentioned. Mr. Eadie undertook the observation of certain stars while they were sufficiently bright to be well seen in his telescope; and when they became too faint for further observation he notified Mr. Parkhurst to begin observing them. When they were again sufficiently bright to be observed by Mr. Eadie, he was informed of the fact by Mr. Parkhurst. This system permitted each observer to employ his time to the best advantage. It is hoped that some astronomer having a large telescope at command will undertake similar observations in co-operation with other observers having smaller telescopes.

Professor Safarik, Prague, Austria. The instrument used previous to March, 1885, was a Newtonian reflector 6½ inches in aperture, with a mirror of silvered glass. The ordinary magnifying power was 32. The finder had an aperture of 3 inches, and a magnifying power of 12. Subsequent observations were made with a refractor by Schröder, with an aperture of 4.5 inches, a magnifying power of 23, and a field of 1° 30′. The obervations were made by the method of Argelander, and on all suitable occasions the colors of the stars were observed upon Schmidt's scale.

Mr. T. S. H. Shearmen, of Brantford, Canada. The instruments employed were an opera-glass and a two-inch refractor. Each variable was compared with stars differing little from it in brightness. Many suspected variables have been photographed.

Mr. E. F. Sawyer, of Cambridgeport, Mass. The observations were made according to the method of Argelander, by means of an opera-glass for the brighter stars, and of a field-glass for the others.

Professor J. F. J. Schmidt, of the Athens Observatory, whose extensive observations of variable stars are preserved in manuscript at the Potsdam Observatory. Professor Vogel, the Director of that Observatory, has kindly facilitated the copying of these observations, and the copy has been transmitted to this Observatory.

Professor Winslow Upton, of Brown University, Providence, Rhode Island. The observations here mentioned were made by Professor Upton during an expedition to observe the total eclipse of the sun which occurred on May 6, 1883. The place of observation was generally on board the U. S. S. Hartford, but occasionally on Caroline Island, in the Pacific Ocean. No instruments except a field-glass were employed in the comparisons, which were made by the division into tenths of the interval between two comparison stars. Most of the observations were independently repeated by Mr. H. A. Lawrance. The stars observed were all south of — 30° declination.

Rev. T. W. Webb, of England. The observations mentioned under this heading were found by Mr. Espin in some of Mr. Webb's manuscripts, and were kindly transmitted to this Observatory.

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Dr. F. Wilsing, of the Potsdam Observatory. The wedge photometer was employed in part of the comparisons, but in such cases estimates in grades of the difference in brightness between the stars compared were almost always added.

An examination of the tables of this paper gives many useful facts, prominent among which are the following:

Table I shows the observations of each star in separate years grouped together, with date, number of observations, and the name of the observer.

Table II is a summary of the detailed information furnished by Table I, and contains also a statement of the position and character of each star as derived from the catalogue of Mr. Chandler, before referred to; also from the ephemerides for 1889 of Professor Schönfeld in *Astronomische Gesellschaft*, and from M. Loewy (Companion to the Observatory, 1889). Dunér's catalogue of spectra, the revised catalogue of variable stars of J. E. Gore (Proceedings of the Royal Irish Academy), and peculiar spectra observed at Harvard College Observatory chiefly, furnish the data for classification in this table. The first column gives the numbers proposed by Mr. Chandler for future designation of variable stars, each number being one-tenth of the number of seconds of time in the right ascension of the corresponding star for the epoch of 1900. Other columns give magnitudes at maximum and minimum, period, date of discovery, day of maximum for 1889, number of observations of each for particular years, and whole number of observations.

Table III shows the observations for the year 1888, and Table IV gives the distributions of observations with annual results.

It would be interesting also to compare the results of this paper with those found in other catalogues before referred to, but want of space forbids. It must suffice now to say that although a vast amount of work has been done in the last few years in studying variable stars, but little has been learned, and that future work should be conducted with greater care and in reference to some definite system if much advancement is to be gained in this new and important branch of astronomy.

ERRORS IN ASTRONOMICAL TEXT-BOOKS.*

LEWIS SWIFT.

For The Messenger.

These strictures are not designed to cast reflections upon the character of any book noticed, nor to indicate the want of ability in any author, and no errors will be noted which are purely typographical in given values in figures, as, perhaps, the omission of a cipher, such as that on page 243 of Professor Young's admirable work, "The Sun," and four different places on page 341 of Professor Mitchel's "Popular Astronomy," where the eminent author was, evidently, not the proof-reader. No doubt, many of the mistakes shown in my former, as well as in this, article have been corrected in subsequent editions of the authors criticised, but for the sake of those who have and read the first publications, I point out errata for correction.

Professor Mitchel, "Popular Astronomy," page 77, says: "4089 years before the Christian era, the perihelion of the earth's orbit coincided with the vernal equinox," and that, "In A. D. 1250, it passed the summer solstice and will meet the autumnal equinox about the year 6483." This will read correctly by changing "vernal" to autumnal, "summer" to winter, and "autumnal" to summer. On page 87, he calls the moon's apogee the least distance from the earth. On page 296 he says: "Encke was the discoverer of Encke's comet." On page 326, near bottom, for "opposition" read superior conjunction.

Brocklesby's Astronomy, page 213, says, writing of double nebulæ, they belong to the class of planetary nebulæ. Though I have observed nearly all the planetary nebulæ visible from this latitude, yet I have never seen a double, and I doubt if the heavens afford a single example.

In Mitchel-Burritt's Astronomy, page 249, regarding the moon's changes, we find the following: "As her enlightened surface comes more and more into view until she arrives at her first quarter and comes to the meridian at sunset, she has then finished her course from the new to the *full*, and half her enlightened hemisphere is turned towards the earth."

* Continued from No. 74, page 194.

Page 158, speaking of a cluster in Sagittarius, says of it: "It is midway between Beta Ophiuchi and Beta Lyræ." Page 163 shows three or four errors. Zeta Herculis is called Delta, and, near the bottom, is named Chi. Also the given right ascension of the cluster is an hour too little. "Heavens Above," by Rolfe & Gillett, page 301, bottom, declares the average number of shooting-stars visible to the naked eye at any one place to be estimated at about one thousand per hour, while at the top of the page the number is correctly given as three or four. Page 221 asserts that there are more lunar than solar eclipses. And on page 148 we find this: "The sun's distance is such that his parallax is about eighty-eight seconds." This error, 88 for 8″.8, cannot be regarded as typographical, since the value is given in words and not in numerals.

"Astronomy Simplified," page 254, says: "Ceres was discovered on the *second* New-year's-day of the present century, Jan. 1, 1801." The author must advocate the erroneous idea—quite a current one—that the first day of this century was Jan. 1, 1800. Had he called to mind that there was no year 0 and that Christ was born in A. D. 1, and that the previous year was B. C. 1, he must have perceived that the 1st of Jan., A. D. 1, was the first day of the first century, and, therefore, that Jan. 1, 1801, was the first day of the nineteenth century.

Lockyer's Astronomy, American edition, page 66, avers the presence of hydrogen in the sun to be doubtful, yet in the frontispiece of the book the positions of two of the five or more hydrogen lines in the sun are shown, and on page 268 it says: "One of the hydrogen lines in the sun is found in the planetary nebula in Draco. Page 35, 1st edition, says of 79 Messier, that it is a nebulous star in Ursa Major, while on page 52, last edition, it is called 79 Ursa Majoris, which is the star Eta, the end star in the handle of the Dipper. Seventy-nine Messier is a resolvable cluster, 24° south of the equator, in Lepus. Mr. Lockyer probably refers to 97 M. which is in Ursa Major though, even then, his statement is erroneous, as it is not a nebulous star but a very remarkable planetary nebula, the largest known.

Under the same head he writes that Epsilon Orionis and 8 Canum Venaticorum are nebulous stars. No modern tel-

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escope shows nebulosity surrounding either. I have frequently examined them with the 16-inch refractor of this Observatory, and have never been able to detect the slightest nebulosity. It is quite strange that these doubtful bodies should have been chosen when the sky furnishes so many striking examples, some of which are visible through small telescopes. Other errors there are, but they are mostly typographic and will be readily detected by an intelligent teacher. Because this work is so excellent, and because of its extensive use in the United States as a text-book, it has given me great pleasure to call attention to its minor faults.

Page 539, Newcomb's Astronomy, (table of periodic comets) "Tempel's I" should read Tempel's II and *vice versa*.

On page 90, Mattison-Burritt's Astronomy (telescopic objects) for Alpha, Beta and Gamma Lupi, read Alpha, Beta and Gamma Leporis. The nebula is also in Lepus.

All text-books on astronomy which have come to my notice convey this misleading statement regarding star-showers, viz.: that they (the falling stars) seem to emanate from one place called the radiant. Now were this assertion made to an audience who had never witnessed a star-shower, a wrong impression would be made. I saw on Nov. 13, 1833, the great shower of that year, and the American side of its return in 1867, and not one in ten thousand in the shower of 1833 *seemed* to radiate from the Sickle in Leo, though their paths, *had they been traced backwards* would have met in the Sickle; a different statement from the other, and one which could not deceive a child. In 1867 a large number were seen low down in the north-west and also many at a rather low altitude in the south-east. Now, it certainly would not be strictly correct to say that they all appeared to start from the radiant, as some of the luminous paths in the north-west were not over a degree in length, but, as we have already seen, their visible tracks traced backwards would converge to the radiant like the radii of a circle to its center.

"Herschel's Outlines of Astronomy," page 521, and Chambers' Astronomy, page 766, give the radiant of the Aug. 9-11 star-shower as B. Camelopardalis. I have, for more than 30 years, been an observer of this shower, and have always regarded an elliptical region (not, as it is often called, a point

about 6° by 12° in Perseus as its radiant. From the radiant being in this constellation, its meteors are called Perseids, as those of the Nov. 14 shower, being in Leo, are called Leonids.

"Herschel's Outlines," page 531: "The Solar Cycle consists of 28 Julian years, after the lapse of which, the same days of the week would always return to the same days of each month throughout the year." It would seem, according to the above rule, that, say, the Fourth of July, would fall on Sunday only once in 28 years, whereas I, myself, have seen ten such instances. July 4th has occurred on Sunday thirteen times during this century, and in 1897 we shall again have a Sunday Fourth. And it is certainly a fact that between the extremes of the Cycle there are three recurrences at irregular intervals of the phenomenon which appear not to appertain to the solar cycle proper. These intervals for them all are 11–6–5–6; 11–6–5–6; 11–6–5–6, etc. Cannot an explanation without ambiguity be given by some one concerning the Solar Cycle?

My own criticism, in a previous article, of Chambers' list of fifteen comets which have twice appeared, is itself erroneous, so far as the last three were concerned, they being the well-known comets of Winnecke, Brorsen and D'Arrest, respectively.

Warner Observatory, May 12th, 1889.

WILLIAM TEMPEL.*

G. V. SCHIAPARELLI.

William Ernest Tempel, astronomer at the Observatory of Arcetri, died on March 16th, after a long and painful illness. His life was a notable example of a strong calling, drawing man with overwhelming force to a fixed object, and surpassing the greatest obstacles.

Born of a poor family, Dec. 4, 1821, at Nieder-Cunersdorf, in upper Lusatia, he early learned the art of lithography, which he followed at first in many cities of Germany, and attained in it great ability united with delicate artistic feeling.

* (From *La Nazione* (Italian) April 5, 1889.) Translated for the MESSENGER by F. W. Fiske, of St. Paul.

Endowed by nature with an imaginative and restless temperament, after a time he left his fatherland to seek his fortune in foreign countries. He lived three years in Denmark, then came to Italy; and in 1859 we find him living in Venice. At this time began his interest in astronomical matters. He purchased with his savings a telescope from Steinheil, not a very large one to be sure, but very good, and he was soon recompensed by his first discovery, the comet of 1859. In the same year he began to make a map of the well-known group of the Pleiades in which in a short time were included six large stars and many hundreds of smaller ones.

How many telescopes since Galileo had been turned to that part of the heavens! Yet aided by the excellence of his instrument and by uncommonly keen vision, Tempel there found that which in 250 years, with telescopes of every size, none had been able to see. He discovered the famous nebula of the Pleiades, whose existence is even now doubtful to many, and he was harshly disputed by those who in astronomy—as is often the case in other departments of knowledge—claim to be the highest critics.

Lately, however, celestial photography has come to confirm the observations of Tempel, and not only removes every doubt of the existence of that nebula, but shows that what Tempel saw is the brightest and thickest part of a nebulous mass extremely complicated and extensive, which extends through nearly all the space occupied by the group of the Pleiades and forms one mass with it. He thus showed in a convincing way the close connection existing between the nebulæ and the stars, and utterly destroyed the belief, still held by Humboldt in his Cosmos, that the nebulæ are collections of stars of a high order, in extent and formation like the Milky-Way, and situated at a much greater distance than ordinary stars.

In 1860 Tempel went to live in Marseilles, and in 1861 served a while as assistant in the Observatory there under the direction of Benjamin Valz. In that position he remained only six months. Loving above everything his own independence, he continued to follow his profession as engraver in that city until 1870, alternating these labors with astronomical investigations. In Marseilles he discovered six small planets, Angelina (64), Maximiliana (65), Galatea

(74), Eurynome (79), first discovered a little before by Watson in America, Terpsichore (81) and Clotho (97); at that time those discoveries had greater fame and greater importance than would be given to them at present. It was then indeed reasonably supposed that the number of the smaller planets between Mars and Jupiter was limited; this does not seem likely to the present astronomers already embarrassed by the mighty army of "*atomi planetarii*," now increased to about 300, and of which no one can see an end. Most important to astronomy were, and always will be, his discoveries of comets, in which he was especially assisted by a very keen eye, the perfect climate of the Provence and the Steinheil telescope of excellent clearness. These are the comets discovered by Tempel in Marseilles: 1860 IV, 1862 I, 1863 IV, 1864 II, 1866 I, 1867 I (with Stephan), 1867 II, 1869 II, 1869 III, and 1870 II (with Winnecke); these gained for Tempel several prizes from the Imperial Academy of Vienna. Of these the most important, from the result to which it led, was 1866 I; which, rather than a comet, should be called a remnant or the ruins of a comet. In the course of the destruction of that body came the thick swarm of bright meteors of November, which at periodic intervals of 33 years meet and surround the earth, producing bright showers of falling stars. We have finally learned the cause of such a phenomenon, which, from the year 902 of the common era even until to-day, has occurred so many times and always been seen with new wonder; and to this progress not a little has been contributed by Tempel's discovery of that burning comet in a very favorable time, just in time to explain the last return of meteors, which was in the night between the 14th and 15th of November, 1866.

The stay in Marseilles marked a very calm and very fruitful period in the life of Tempel, to which, unfortunately, the political whirlwind of 1870 put too early an end.

Expelled from France for no other offence than that of being a German, in the beginning of 1871 he went to Milan where he was established as assistant in the Royal Observatory of Brera. Then giving up the art of lithography he gave himself wholly to science, and in his new field of work engaged in useful labors. In the four years that he stayed in Milan (1871–1874) he discovered four

more comets, 1871 II, 1871 V, 1871 VI, 1873 II. Besides these, he observed and drew several other comets, particularly the splendid one of Coggia that appeared in 1874, whose appearance he represented in a way that has not yet been excelled.

Though so tireless a hunter of comets, Tempel in the number of his discoveries did not rival Pons, to whose life his own presents many analogies. Yet it may be said that no astronomer has made discoveries in this line more important and more useful.

I have already shown how timely and how fruitful in its results was his discovery of the comet 1866 I; to this I should add that, of the ten comets of short periods yet known, three are due to Tempel. The story of these comets belongs to the most interesting part of astronomy. The changes through which, by the powerful attraction of the larger planets (for the most part of Jupiter), they were drawn in periods sometimes not very distant, to become lasting members of the planetary system; the exact forces whose application has caused these disturbances through the planetary bodies; the notions that some of them have given and can still give in the future about a supposed resisting ether filling all the heavenly space; and, finally, the destruction that one of them, Biela's, and perhaps also Vico's, has suddenly undergone, as if before our eyes separating into small fragments; all these questions give to these bodies of feeble light and modest appearance a degree of importance not inferior to the largest and brightest comets.

His age and the state of his health made his labors very severe, continuing nightly observations in the trying climate of Milan; and in the beginning of 1875 he was led to accept the position of astronomer in the new Observatory founded by Donati a few years before in Arcetri, where he lived and worked alone, expecting a definite arrangement at that fine Observatory. There at first he continued his assiduous investigations of comets; his last discovery in this field was the comet 1877 V. Finding himself entirely his own master and having two large telescopes by Amici that were distinguished for the clearness of their images, he gave himself, with the zeal that he put in every act, to the study of the nebulæ, whose forms and details he represented in a large

number of drawings, which are the finest and the most accurate yet made in this line.

For this labor he was thought, in 1880, worthy of the Royal prize which the Royal Academy gives every six years to astronomical work. So perfect are these drawings that Tempel in vain sought an artist capable of reproducing them satisfactorily to him; and they are among his unpublished works; but their existence and their value are not unrecognized in the astronomical world, and already a movement has been made in Germany to acquire and publish them.

The reason for so great an interest in them is not hard to find, for besides an eye skilled in astronomy Tempel had a practised artist's hand; two qualities that are rarely both found to so high a degree in the same person. The drawings of the nebulæ that he left are, in the opinion of all who have seen them and compared them with the heavens, a faithful representation of the appearance presented by the nebulæ to a telescope of the present time. Therefore they can give to astronomers in the future a means of judging upon the question of the possibility of change in these bodies; which perhaps we could now do, had there been a Tempel provided with a telescope upon the Nile with the builders of the pyramids, or in an Observatory upon the roofs of the temples of Babylon. It is then of great importance not to allow to perish or become forgotten a work whose value will always increase with the ages.

One might think that photography applied to representing the heavenly bodies would now render useless drawings made by the aid of the telescope. But let me say that is an error; for those rays or vibrations of light by which the heavenly bodies are made visible to the human eye are generally different from those oth rays by means of which these bodies are figured upon photographic plates. So it can happen that a star in which at first sight prevail rays of great intensity appears very bright to our eyes and yet acts with feeble impression on the plate of the camera. On the other hand another heavenly body, whose light abounds in chemical rays, can act with strong effect upon the photographic plate and yet be hardly visible to the human eye, or entirely invisible. There are such essential differences existing in the

character of the light emitted by different stars, and also by different nebulæ; and they can exist in different parts of the same nebula, which will appear of different aspect whether seen by the eye or photographed. A remarkable instance is seen in the case of the nebula of the Pleiades, which in a photograph shows an appearance quite different from that seen through the telescope. Not only therefore will the drawings of the nebulæ made by the eye in the usual way never be useless, but when they are compared with the photographic impressions there will rise very instructive ideas about the different characters of the nebulæ.

In the last years of his life Tempel was obliged to give up entirely night observation as too fatiguing to his declining health. The impossibility of completing these tasks, which would bring him the greatest fame and happiness, contributed not a little to increase his illness. After a year's sickness a sudden crisis ended his sufferings on the 16th of March, 1889.

Although Tempel had not received a regular education he was not wholly without culture; he had a strong love of nature and art, and poetry made a strong impression upon him. In mathematics he had, without the aid of teachers, and by himself, mastered the first steps, and was never troubled in making the needed calculations.

His honesty of character made him worthy of high esteem; but his mind was very sensitive and ill fitted to bear the inevitable disagreements caused by daily contact with his fellows; nor had he learned the necessary art of bearing them philosophically. He often kept himself brooding over injuries, and sometimes without any real cause; and this produced the impression in those who did not know him that he was a distrustful and unaffable man. Only a long acquaintance with his character could correct this judgment and give a just estimate of his faults, which injured no one but himself and were fully compensated by the strength of his noble qualities.

His friends cannot forget his pure and disinterested love which made of a humble workman a wise astronomer, gaining for his memory a name that will last as long as the study of the heavenly bodies is held in honor by men.

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CURRENT INTERESTING CELESTIAL PHENOMENA.

THE PLANETS.

Mercury comes into inferior conjunction with the sun on the morning of June 19. The planet will then be about four degrees south of the sun, and so not visible. From July 5 to 20 Mercury will be visible in the morning an hour before sunrise, a little to the right and above the sunrise point. He will be visible at greatest elongation west from the sun, 20°47′, on the morning of July 12.

Venus rises from two to three hours earlier than the sun, so that she is in favorable position for morning observations. She will be in conjunction with the moon, 1° 01′ north, June 23 at midnight; in aphelion June 25; at greatest elongation west from the sun, 45°44′, July 10; in conjunction with Neptune, July 10 at 10 P. M., the latter being then 1°48′ north of the former.

Mars sets a few minutes later than the sun, and so cannot be seen.

Jupiter is now in best position for observation this year, coming into opposition to the sun June 24, and visible during the whole night. *The Observatory* for May, 1889, contains a review of some observations of this planet made in the years 1881-86 at Birr Castle Observatory, Parsontown, Ireland, and published in Vol. IV of the "Scientific Transactions of the Royal Dublin Society." Eighty complete drawings and four sketches of Jupiter were made with a reflector of three feet aperture by Dr. Otto Boeddicker. The drawings were executed in pencil, the average time devoted to each being not more than ten minutes, and are reproduced, without retouching or correction in any way, by a photo-mechanical process, so that errors of lithography are thus avoided.

Saturn sets too early in the evening to be well seen. He will be in conjunction with the moon, south 2°, July 1 at 1 P. M. Reports still come in of observations of the white region upon the rings of Saturn seen in March. Several astronomers seem unwilling to admit that the appearance seen was due to the effect of contrast or bad atmospheric conditions; yet after reading carefully all the accounts at

hand, we are inclined to believe that nothing has been seen but what would, in the absence of Dr. Terby's announcement, have been set down as the result of one or both of those causes.

Uranus will be in quadrature, *i. e.* 90° east from the sun, July 9. He crosses the meridian early in the evening, and may be found near θ Virginis, the nearest naked-eye star northwest of Spica.

Neptune may be seen again in the morning, 5° south of the Pleiades, rising from two to three hours before the sun. The conjunction of Neptune with Venus has been mentioned above. He will be directly north of the moon, about 1°46′, on the morning of June 24.

MERCURY.

	R. A. h m	Decl. ° ′	Rises. h m	Transits. h m	Sets. h m
June 20.....	5 49.7	+19 20	4 29 A.M.	11 53.1 A.M.	7 18 P.M.
25.....	5 39.5	+18 45	4 02 "	11 23.3 "	6 45 "
30.....	5 35.1	+18 48	3 38 "	10 59.3 "	6 21 "
July 5.....	5 38.8	+19 25	3 19 "	10 43.3 "	6 08 "
10.....	5 51.5	+20 25	3 07 "	10 36.5 "	6 06 "
15.....	6 13.3	+21 30	3 04 "	10 38.4 "	6 13 "

VENUS.

June 25.....	3 11.8	+14 23	1 54 A.M.	8 56.0 A.M.	3 58 P.M.
July 5.....	3 46.8	+16 24	1 41 "	8 51.7 "	4 02 "
15.....	4 25.9	+18 23	1 31 "	8 51.2 "	4 11 "

MARS.

June 25.....	6 08.3	+24 11	4 04 A.M.	11 53.0 A.M.	7 42 P.M.
July 5.....	6 38.5	+24 01	3 55 "	11 42.9 "	7 31 "
15.....	7 07.2	+23 31	3 74 "	11 32.2 "	7 17 "

JUPITER.

June 25.....18	14.0	−23 15	7 32 P.M.	11 55.7 P.M.	4 20 A.M.
July 5.....18	08.5	−23 18	6 47 "	11 10.9 "	3 35 "
15.....18	03.4	−23 20	6 03 "	10 26.6 "	2 50 "

SATURN.

June 25.....	9 21.7	+16 38	7 52 A.M.	3 05.1 P.M.	10 18 P.M.
July 5.....	9 26.0	+16 18	7 20 "	2 30.0 "	9 40
15.....	9 30.5	+15 57	6 46 "	1 55.2 "	9 04 "

URANUS.

June 25.....13	06.9	− 6 26	1 11 P.M.	6 49.4 P.M.	12 27 A.M.
July 5.....13	07.0	− 6 28	12 32 "	6 10.4 "	11 48 P.M.
15.....13	07.5	− 6 31	11 54 A.M.	5 31.6 "	11 09 "

NEPTUNE.

June 25.....	4 05.9	+19 14	2 26 A.M.	9 50.2 A.M.	5 14 P.M.
July 5.....	4 07.4	+19 17	1 48 "	9 12.3 "	4 36 "
15.....	4 08.5	+19 20	1 10 "	8 34.1 "	3 58 "

THE SUN.

	R. A.	Decl.	Rises.	Transits.	Sets.
	h m	° ′	h m	h m	h m
June 20.....	5 57.9	+23 27	4 15 A.M.	12 01.4 P.M.	7 48 P.M.
25.....	6 18.7	+23 23	4 16 "	12 02.4 "	7 49 "
30.....	6 39.4	+23 09	4 18 "	12 03.5 "	7 49 "
July 5.....	7 00.1	+22 44	4 21 "	12 04.4 "	7 47 "
10.....	7 20.5	+22 10	4 25 "	12 05.1 "	7 45 "
15.....	7 40.8	+21 26	4 29 "	12 05.7 "	7 42 "

Occultations Visible at Washington.

Date.	Star's Name.	Magnitude.	IMMERSION. Wash. Mean T.	IMMERSION. Angle f'm N. P't.	EMERSION. Wash. Mean T.	EMERSION. Angle f'm N. P't.	Duration.
			h m	°	h m	°	h m
June 17	56 Aquarii	6½	13 40	49	14 53	269	1 13
19	B. A. C. 17	6	12 31	80	13 24	281	0 53
July 6	88 Virginis	6½	10 02	190	10 22	204	0 20

Phases of the Moon.

	Central Time. d h m
Last Quarter.....	June 20 1 35 A.M.
New Moon.....	June 28 2 54 A.M.
First Quarter.....	July 5 11 59 P.M.
Full Moon.....	July 12 3 02 P.M.

Phenomena of Jupiter's Satellites.

Central Time. d h m		Central Time. d h m	
June 18 2 33 A. M.	I Sh. In.	June 11 56 P. M.	II Tr. Eg.
2 43 "	I Tr. In.	July 1 12 15 A. M.	II Sh. Eg.
11 56 P. M.	I Ec. Dis.	4 12 36 "	I Tr. In.
19 2 18 A. M.	I Oc. Re.	12 50 "	I Sh. In.
3 50 "	III Ec. Dis.	2 53 "	I Tr. Eg.
9 01 P. M.	I Sh. In.	3 06 "	I Sh. Eg.
9 09 "	I Tr. In.	9 56 P. M.	I Oc. Dis.
11 18 "	I Sh. Eg.	5 12 25 A. M.	I Ec. Re.
11 25 "	I Tr. Eg.	7 02 P. M.	I Tr. In.
20 8 44 "	I Oc. Re.	7 19 "	I Sh. In.
21 11 56 "	II Ec. Dis.	9 19 "	I Tr. Eg.
22 2 39 A. M.	II Oc. Re.	9 35 "	I Sh. Eg.
8 30 P. M.	III Sh. Eg.	7 12 20 A. M.	III Tr. In.
8 39 "	III Tr. Eg.	1 33 "	III Sh. In.
23 9 39 "	II Sh. Eg.	3 13 "	III Tr. Eg.
9 41 "	II Tr. Eg.	8 52 P. M.	IV Tr. In.
26 1 46 A. M.	I Oc. Dis.	9 38 "	IV Tr. Eg.
4 02 "	I Ec. Re.	11 32 "	II Tr. In.
10 52 P. M.	I Tr. In.	11 36 "	IV Sh. In.
10 56 "	I Sh. In.	8 12 12 A. M.	II Sh. In.
27 1 09 A. M.	I Tr. Eg.	12 55 "	IV Sh. Eg.
1 12 "	I Sh. Eg.	2 11 "	II Tr. Eg.
8 12 P. M.	I Oc. Dis.	2 52 "	II Sh. Eg.
10 31 "	I Ec. Re.	9 8 59 P. M.	II Ec. Re.
28 7 41 "	I Sh. Eg.	11 11 40 "	I Oc. Dis.
29 2 15 A. M.	II Oc. Dis.	12 2 20 A. M.	I Ec. Re.
9 03 P. M.	III Tr. In.	8 47 P. M.	I Tr. In.
9 34 "	III Sh. In.	9 13 "	I Sh. In.
11 56 "	III Tr. Eg.	11 03 "	I Tr. Eg.
30 12 29 A. M.	III Sh. Eg.	11 30 "	I Sh. Eg.
9 17 P. M.	II Tr. In.	13 8 49 "	I Ec. Re.
9 36 "	II Sh. In.		

Approximate Times of Transit of the Great Red Spot Across the Middle of Jupiter's Disk.

	Central Time. d	h	m		Central Time. d	h	m		Central Time. h	d	m	
June	16	12	07	A. M.	June 26	6	12	P. M.	July 7	2	22	A. M.
	16	7	58	P. M.	27	11	59	"	7	10	14	P. M.
	18	1	45	A. M.	28	7	50	"	8	6	05	"
	18	9	36	P. M.	30	1	37	A. M.	9	11	52	"
	20	3	23	A. M.	30	9	28	P. M.	10	7	43	"
	20	11	14	P. M.	July 2	3	15	A. M.	12	1	30	A. M.
	21	7	05	"	2	11	06	P. M.	12	9	21	P. M.
	23	12	52	A. M.	3	6	58	"	14	3	08	A. M.
	23	8	43	P. M.	5	12	44	A. M.	14	10	59	P. M.
	25	2	30	A. M.	5	8	36	P. M.	15	6	50	P. M.
	25	10	21	P. M.								

Ephemeris of Variables of the Algol-Type.

Approximate Greenwich M. T. 1889.

From the Astronomical Journal, No. 193.

	June. d	h		June. d	h		June. d	h
U Cor. Bor.	1	9	U Ophiuchi	11	12	U Ophiuchi	19	21
U Ophiuchi	1	11	U Cor. Bor.	11	18	U Ophiuchi	20	18
Y Cygni	1	18	Y Cygni	12	6	Y Cygni	21	6
Y Cygni	3	6	δ Libræ	12	18	U Ophiuchi	21	14
δ Libræ	3	10	Y Cygni	13	18	Y Cygni	22	18
U Cephei	4	12	U Cephei	14	11	Y Cygni	24	6
Y Cygni	4	18	U Ophiuchi	14	21	δ Libræ	24	9
U Ophiuchi	4	19	Y Cygni	15	6	U Cephei	24	10
U Cor. Bor.	4	20	U Ophiuchi	15	17	U Cor. Bor.	25	13
U Ophiuchi	5	15	U Ophiuchi	16	13	Y Cygni	25	18
Y Cygni	6	6	Algol	16	17	U Ophiuchi	25	19
U Ophiuchi	6	11	Y Cygni	16	18	U Ophiuchi	26	14
Y Cygni	7	18	δ Libræ	17	9	δ Libræ	26	17
Y Cygni	9	6	Y Cygni	18	6	Y Cygni	27	6
U Cephei	9	11	U Cor. Bor.	18	15	U Ophiuchi	27	11
U Ophiuchi	9	20	U Cephei	19	11	Y Cygni	28	18
δ Libræ	10	10	Algol	19	14	U Cephei	29	10
U Ophiuchi	10	16	δ Libræ	19	17	Y Cygni	30	6
Y Cygni	10	18	Y Cygni	19	18	U Ophiuchi	30	19

Ephemeris of Comet B 1889 (Barnard Mar. 31.) From the elements of Dr. Krueger as given in A. N. 2893, I have computed the following ephemeris of Barnard's Comet:

	Gr. M. T.	R. A. h m s	Dec. ° ′	Log r.	Log Δ.
June	1.5	5 7 21	+14 4.2	0.3529	0.5111
	7.5	7 22	+13 47.5	0.3524	0.5109
	13.5	7 24	+13 30.9	0.3520	0.5107
	19.5	8 12	+13 10.9	0.3524	0.5067
	25.5	9 1	+12 50.9	0.3529	0.5028
July	1.5	9 19	+12 28.2	0.3539	0.4967

O. C. WENDELL.

Harvard College Observatory, May 13, 1889.

An Annular Eclipse of the Sun will occur June 28, beginning at 6*h* 06*m* A. M. and ending at 11*h* 54*m* A. M., Green-

wich mean time. It will be visible in southern Africa and the South Atlantic and Indian Oceans, the northern limit of the eclipse reaching to Arabia, Hindostan and the East India Islands. The moon will be at apogee June 27 and the earth at aphelion July 1. The sun's diameter at the time of the eclipse will be 2′ 02″ greater than that of the moon.

A Partial Eclipse of the Moon, invisible in the United States, but visible generally in Europe, Asia, Africa, Australia and the Atlantic Ocean and the easterly portion of South America, will take place July 12, beginning at $6h$ $33m$ P. M. and ending at $11h$ $15m$ P. M., Greenwich mean time. Magnitude of eclipse 0.486 diameters of the moon.

The Extent of the Corona of The Sun, as seen in the eclipse of Jan. 1, 1889, is well stated in the following paragraph by Professor Holden:

"So far as I know, no photograph of the corona has traced these wings further from the center than fifty minutes of arc. Out to that distance they seem to be convergent and to indicate that they quickly come to an end. Mr. Barnard's photographs, however, show faint extensions as far out as seventy-five minutes of arc, and it is evident that the outer corona, instead of quickly terminating, must extend far into space. The pictures show this divergent outer extension in a form like that of a fan, or like the open mouth of a trumpet. This, of course, indicates that the outer corona is in the shape of a huge disk, surrounding the whole sun, with its outer rim much deeper than its inner one. In fact, if the sun were surrounded by a ring of meteorites, the appearance would be much the same as in the photographs."

Solar Activity in 1888. From a late number of *The Journal of the Liverpool Astronomical Society* some interesting facts are taken pertaining to solar activity. In that article it is claimed that the behavior of the various orders of solar phenomena, spots, faculæ, and prominences, during the year 1888, show conclusively that the minimum must be near at hand. The evidence of this from the sun-spots is that they are few in number, small in size and low in latitude, with considerable intervals in which no spots at all

are seen. These statements are supported by comparative tables taken from the observations by Tacchini in the *Comptes rendus*. It is interesting to notice that, while the faculæ have not varied simultaneously with the spots, their diminution since 1886 and 1887 has been slight, while that of the hydrogen prominences has been more pronounced. The magnetic variation has shown a decline parallel to that of the sun-spots.

Burnham on the Trapezium of Orion. At the April meeting of the Royal Astronomical Society, a paper titled the "Trapezium of Orion," written by Astronomer Burnham of Lick Observatory, was read and discussed. The points made in the paper, as reported by the *Observatory* were, that perhaps no object in the heavens had received so much attention as this, and that no equal area had furnished room for so many purely imaginary stars; that most of these so-called discoveries had been made with small telescopes and by inexperienced observers, but that the largest and most perfect refractors, in the hands of skilled observers, had utterly failed to show a single one of these supposed new stars; that an observer with a 12-inch mirror believed he saw nine or ten stars in the Trapezium which Mr. Burnham, with the Chicago 18½-inch telescope, and Professor Hall, with the Washington 26-inch could not see. When the 36-inch equatorial of Lick Observatory was mounted Alvan G. Clark found a small star in the Trapezium (see February MESSENGER, 1888) which Mr. Burnham has since repeatedly seen and measured, though extremly faint and difficult, as it seemed to be near the limit of visibility by the 36-inch; that Mr. Barnard last October found another new star just preceding the Trapezium, this star being double, and afterwards measured by Mr. Burnham; that Mr. Barnard had also discovered a second star within the Trapezium which was much fainter than the others, and which Mr. Burnham had not succeeded in observing for want of favorable conditions.

In the discussion of the paper Capt. Noble disagreed with the views of Mr. Burnham on one point, claiming that the fifth and sixth stars of the Trapezium were certainly variable and gave strong proofs of his position. This view was

also held by Professor Chambers and others of the Royal Society.

Brilliant Meteor. On the evening of May 15, while walking on Broadway, Oakland, a street brilliantly lighted by electric arcs, and in the light of the full moon just risen, at 8*h* 40*m* Pacific Meridian, I saw a very large and brilliant meteor or fire-ball which came, as nearly as I could estimate, from a point midway between the stars Gamma and Alpha Leonis. It pursued a southerly course along an arc drawn through those stars and seemed to disappear at a point about half way between Regulus and α Hydræ. Then instantly it reappeared just a very little farther on, became quickly as bright as ever, *wabbled* from east to west as it flew on and down, turned in a hooked path toward the west and almost instantly disappeared about six degrees directly north of α Hydræ.

Its motion was very rapid, the total interval of time from appearance to final extinction being, by my estimate, not more than one second. Its trail at no time was very long, and died out quickly, but was the broadest that I have ever seen, and was uneven or *humpy* at different parts of its length seen at the same instant. The *wabbling* motion or vibration before mentioned was very marked and there was an evident tendency to drift toward the west. The hooked path at the time of extinction was short and faint, the last direction being about at right angles to the long path, but was a well marked deflection from it.

The head and trail of the fire-ball had the same color; namely, a yellow as seen through a green mist or vapor.

The intensity of the light was about that of Saturn, but the apparent size of the fire-ball was that of Venus at time of greatest brilliancy.

FRANK SOULE.

Students' Observatory,
Berkeley, Cal., May 16, 1889.

The Trisection of the Arc. We have received a pamphlet from Michael H. Brennen of Devil's Lake, Dakota, entitled "The Trisection of the Arc." Most of our readers probably know that the problem of trisecting an arc is very old, and that the ancient geometers were unable to solve it by the

ordinary methods of geometry as then known. It was only by the aid of the higher plane curves that the solution was found, and in this, Diocles, the inventor of the "Cissoid," and Nicomedes, the author of the "Conchoid," were the leaders. The latter lived in the second century of the Christian era, and the former in the sixth. That which led to the discovery of these two different and interesting curves was the persistent endeavor of these scholars to find a method of trisecting an angle, and for constructing two geometrical means between two straight lines and ultimately to construct a cube double a given cube.

The Cissoid of Diocles referred to rectangular coördinates gives an equation of the third degree, while the Conchoid of Nicomedes is a locus of the fourth, and yet both solve the problem of duplicating the cube, or trisecting the angle, because they are essentially one problem. Later Sir Isaac Newton gave an elegant mechanical method of producing the Cissoid by continuous motion, which is found in Lardner's Algebraic Geometry. This curve has also been shown to be the locus of the vertex of a common parabola rolling in an equal parabola. With these leading points pertaining to the history of this problem let us turn to Mr. Brennen's work and see what has been added in the way of method or principle to that which is already known.

Starting with the eqation $x^3 - 3x + m = 0$ (1), in which x has one real value, suppose $x = y$; then $x - y = 0$. Depress the former equation by dividing by the latter and the result is $x^2 - xy + y^2 - 3 = 0$ (2). Equation (2) represents an ellipse with the semi-axis inclined 45° to rectangular axis of reference in the negative direction. The semi-axes of the ellipse are respectively the $\sqrt{6}$ and the $\sqrt{2}$, and the curve cuts the axes of reference at $\pm\sqrt{3}$ for both, and the foci are each 2 from the center.

The next step taken by the author is to show that this equation of an ellipse is the locus of the intersection of a plane with the convex surface of a right cylinder. The triangle formed by the oblique plane of the ellipse, the base of the cylinder and a perpendicular from the upper vertex of the ellipse is right angled, with sides respectively $\sqrt{3}$, 1, $\sqrt{2}$, and is called "the mystic triangle." This triangle is the key to the solution of the problem under consideration, by the

author's method. Chiefly by the use of this, the connection between the chord of the given arc, as shown on a perpendicular transverse section of the cylinder and the point on the ellipse whose ordinate represents the value of the chord of one-third of the arc is determined.

In doing this some very interesting relations appear in the author's work. Referring to the cubic equation again, it apears that the three roots under consideration are all real, and that their sum is equal to zero, although Cordan's process of solving the equation shows that x is apparently imaginary. Now, if a curve is produced by the intersection of what is called a trisecting radius with the chord of a whole arc, or such chord produced, the locus closely resembles the Lemniscate of Bernoulli. But the Lemniscate is the locus of the intersection of a perpendicular from the origin on the tangent to the equilateral hyperbola, and it is well known that the square of the ordinate of a hyperbola is to the rectangle of the distances from its foot to the vertices, as the square of the semi-conjugate axis is to the square of the semi-transverse axis. Now, if $A = \frac{1}{3}\sqrt{3}m$ and a point T on the ellipse is conicidently in the axis of the cone and hyperbola, the distance from such point to the vertex is also A. Then this proportion will follow:

$$m^2 : \tfrac{1}{3}\sqrt{3}\, m \,.\, \sqrt{3}\, m :: B^2 : \tfrac{1}{3}\, m^2$$
$$\tfrac{1}{3}\sqrt{3}\, m = A,\ e = \sqrt{2},\ P = A.$$

We have not given this interesting paper the full attention it deserves. Its successive steps in development ought to have been illustrated by approximate figures. It seems to us that Mr. Brennen's work on this interesting old problem has in it points of originality that show a high order of analysis in dealing with conics.

Encourage Young Observers. Within the last few months we have received many letters from young observers, giving account of what they have seen with their own instruments. The observations have generally been on objects familiar to astronomers, and many of the things seen entirely commonplace and not important enough for public notice. But it has been our purpose constantly to answer all such letters with a word of encouragement, and a suggestion or two in the line of the student's thinking and work, so as to

help him to persevere; because it is no easy task to start in observing on astronomical studies and depend on one's self largely for guidance. Where one will succeed ten will fail. The circumstances are not improved for such students if astronomers make light of their weak attempts, or answer occasional queries from them in such a way that there will be no desire to get help from that source any longer. A worthy young man has recently been so unkindly treated, in this particular, that the following sentence I know to be but a part of the sting keenly felt by him: "I am glad to receive some encouragement from such a reliable source; to tell the truth, I had almost resolved not to say anything more about my observations, but to keep them to myself in the future."

Not long ago, while attending a public meeting of scientists, one physicist of national reputation in the course of his paper, took occasion to berate the small Observatory whose telescope was used "to look at the moon with" in a very remarkable manner, claiming how much better it would be to turn all funds used for such purposes into one large institution of national character and for the aid of great achievements in pure science. His was a lofty period of irony, and no doubt its effect was to make the little scientists wish they had staid at home if any had been guilty of dabbling with small things at any time. Others might lose their patience and think (if they did not say) such rhetoric is nonsense and had better be omitted from the deliberations of scientific societies.

New Edition of Chambers' Descriptive Astronomy. From a private letter, dated April 15, by Professor G. H. Chambers, Northfield Grange Observatory, East Bourne, Sussex, England, we learn that a new edition of his Descriptive Astronomy is to appear very soon. His numerous American friends and correspondents may not all know that the first volume of this new fourth edition was expected to be published during the month of May. The high place that the third edition of his astronomy has held in the opinion of American scholars is ample guaranty that the new edition of this standard work will find ready and general sale in America.

XUM

The Pond Motor Astronomical Clock. We were so much interested in a recent account given us of the study of Observatory time-keeping by Mr. Chas. H. Rockwell, of Tarrytown, N. Y., that we append a full report of it for the benefit of our readers.

Five years ago, when he first received his almucantar, he commenced a series of experiments on clocks. The almucantar itself was then an experiment, but he found its use for time determination more satisfactory than the transit instrument. It is not worth while, here, to give a list of the batteries, motors, escapements and pendulums which he tried and discarded before coming to his present combination. All his experiments, however, have been with electric clocks in one form or another. He considers it a very great advantage to be able to avoid going frequently into the clock-room, and to free the movement from even the small disturbance of winding with a key. Certainly it is no disadvantage to the clock *to be let alone.*

In the present instance he locked up the clock-room on the 8th of November last, and the door was not re-opened until April 22d, when he found everything in good condition. The power is supplied by three Laclanche cells, conveyed to the motor by about fifty feet of No. 14 copper wire. The Pond motor winds the train *each hour*, using the spring more gently and more uniformly than if it were required to run for twenty-four times as long a period.

The escapement was invented by Mr. Jas. H. Gerry, who was for a number of years the foreman of the Howard Clock Co., Boston.

It is an improved form of the well-known gravity escapement, presenting, however, some peculiarities which commend it to him over any other form with which he is acquainted.

One of these is the opportunity to change the arc of vibration of the pendulum. The pendulum is now swinging 2° 20′ from the center.

Some day he hopes to be able to undertake a series of experiments in this line, to learn whether better results can be obtained with a large arc or a small arc.

The pendulum he is using was made from his own drawings, by Messrs. Warner & Swasey, of Cleveland. The jar is

three inches in diameter by nine inches deep inside, and was bored out of a solid bar of steel.

He is using thirty-one and a half pounds of mercury. Taking an ordinary Frodsham pendulum as a standard, he has dispensed with the *thumb-hold*, also with the *jam-nut*, also with the *sleeve*, on which the regulating screw is cut; discarding especially the clumsy pointer which we sometimes see. The regulating screw is cut on the rod itself, which is three-eighths inches in diameter. This screw is received in the *nose* of the top of the jar, and the whole jar is turned up or down, as may be required. In looking at the memorandum of the running of the clock one will notice changes in the *sign* of the daily rate.

A week of warm weather, Aug. 30 to Sept. 5, gave a continuance of the small *gaining* rate. A few days of cool weather, Sept. 5 to Sept. 13, gave a small *losing* rate. This indicated too much mercury in the jar, so he took out thirty-seven grains.

He is now working at the problem to find the proper amount of mercury for temperature correction, to compensate the expansion and contraction of the pendulum-rod.

Camden Astronomical Society. From a recent private letter we are informed that, in Camden, N. J., an Astronomical Society has been formed, of which there are now eleven members. The society owns a complete Observatory with a 5½-inch equatorial, transit instrument, chronograph, sidereal clock, and the various accessories in the way of micrometers, solar eye-pieces, etc. They have also ordered a spectroscope which, when completed, will about finish their outfit. The society was incoporated in April of last year. The officers are E. E. Read, Jr., president; A. B. Depuy, secretary.

January Total Eclipse. In our report of C. W. Irish's observation of the total solar eclipse of Jan. 1, 1889, it was an oversight not to have given the size of the telescope used. It was a 4-inch objective, 42½ inches focal length. Powers 75 to 250. In observing first and fourth contacts, power 75 was used.

XUM

Lunar Study near Plato. Just under Plato is a square enclosure, sometimes called the "battlements." It is bounded on two sides by high ridges, on the other two by those which are very much lower, one of which is barely visible. Just in the shadow of the highest is the form of a cross, which is a very curious object. It is not more than about four miles each way but it is almost perfectly symmetrical. To me it looks as though it were very high in the centre and sloped towards the ends of the arms. It can be seen when the terminator is just beyond Copernicus, and well repays search. I looked a long time in vain to see it, but never at just the right time. When it is near the terminator I judge it is hidden in the shadow of the wall, and after the sun gets above it, it disappears completely from want of contrast with the small shadow it throws. Webb mentions it, but says he never succeeded in seeing it.

A. B. D.

Satellites of Uranus. While at the Observatory of a friend on the evening of June 6, 1888, I turned the 6¼-inch refractor, an admirable glass by Cook, upon Uranus, and saw near the planet, at first *one*, later in the evening, *two*, faint stars, "glimpse stars," so to speak. They were very unsteady, yet I presumed them to be the satellites, Oberon and Titania. The time of the observation was 8*h* 20*m* mean time, Elizabeth, N. J. Micrometric measurements gave their respective distances about 93″ and 149″, which were recorded. Several evenings later their distances had become greater, and soon one was invisible, but every measurement showed a widening distance. I therefore concluded that the objects could not belong to Uranus, but were stars over which the planet was moving. HENRY HARRISON.

South Bergen, May 16, 1889.

Wolsingham Observatory. The spectra of R Leonis and R Hydræ contain bright (hydrogen?) lines, first seen on Feb. 25th. Observation confirmed, through the kindness of Mr. Common, by Mr. Taylor, at Ealing, who sees two in R Leonis and one in R Hydræ. T. E. ESPIN.

April 2, 1889. Circular No. 23.

EDITORIAL NOTES.

Our readers will please remember that July and August, or September, are usually vacation months, and that the MESSENGER will not be published for two of these months. In making up annual files for binding, the consecutive numbers will always be found on the first page of the cover, and the first page of the reading matter of each issue.

It is also asked that our friends in the list of foreign subscribers will please remember to draw all post-office orders for remittances on either the offices at Faribault, Minn., or St. Paul, Minn., and not on the office at Northfield, New York, or any other, for the first is not a foreign money-order office, and collections from others are inconvenient.

We have greatly desired for a long time to add some new features to the MESSENGER which seem to us desirable, to increase its usefulness and general interest in it. We refer now particularly to the feature of biographical sketches and suitable engravings of the great astronomers of the world and possibly other noted men in kindred scholarly pursuits, especially those who have contributed largely to the past or present growth of astronomical science, although their chosen life work may have been in some other profession. We feel special interest in this feature, not only for the variety of contents that it may give to each volume of the MESSENGER, but also because that if such work be well and systematically done it will be a contribution to the history of our science that is now lamentably neglected. In order to present as many as ten fine engravings each year and to secure the best biographical sketches possible, considerable expense will be involved, yet it is believed that our subscribers will not object to a slight increase of subscription price if so valuable a feature as this and some others should be added in way of compensation.

During the last two months the attention given to eclipse reports and other current topics has so filled our space as practically to crowd out the long list of queries on astronomical themes that have come to our table from various

sources, including the professional astronomer, as well as the amateur. This phase of current thought will be resumed again in our next publication.

The Parallax of 61 Cygni. Under date of May 1, 1889, in *Astronomische Nachrichten*, No. 2895, we notice that W. T. Lynn has rightly called attention to the omission of Professor Asaph Hall's determinations of the parallax of 61 Cygni in the list of such determinations given by Mr. Belopolsky. Professor Hall's measures were made in two series, one in 1885–6 and the other in 1880–1, and published in the Washington Observations for 1883 in the year 1887.

Mr. Lynn also says that Mr. Belopolsky has inserted a value by Dr. Gill of 0″.50, but that value is not the result of a determination, as readers might suppose, but is apparently taken from an article by Dr. Gill on parallax in the Encyclopedia Britannica, in which he mentions that as probably the best result from all the determinations. But Professor Hall's investigation, which gave a result of 0″.27 ± 0″.01, makes it probable that the true value is smaller. Some time ago we called attention to the important work of Professor Hall in the study of the parallax of this star.

Chandler on Variable Star Phenomena. In speaking of the work on variable stars at Harvard College Observatory (in another place in this issue) during the last four years, we had not then seen the article by Mr. Chandler in the *Astronomical Journal*, No. 193, entitled, "On the general relations of variable star phenomena." From that interesting article we gather the following points of general interest: That a comparison of the phenomena of the variable stars naturally begins with a knowledge of that set of relations that spring from periodicity, such as the coördination of the lengths of the periods with the number of variables, with their color, with their range of fluctuation, with the forms of their light-curves and the irregularities of their period and of the light-variations. The number of known variable stars is yet small for thorough or exhaustive comparison in all these particulars, and hence some conclusions will be uncertain, but there are others that are established beyond doubt.

1. It was known long ago that variable stars differ

widely in the length of their periods of light-variation. This is not a chance relation, but doubtless exists in the nature of the bodies themselves. This inference is drawn from a table showing three classifications, "the first by Schönfeld in 1863, with 71 periods known; the second in 1875, with 101 known periods" by the same astronomer, and the last with 160 periods by Mr. Chandler in 1888. From this table the excess of short periods is apparent, even after we exclude the nine stars of the Algol-type. The maximum of the long period variables lies at about 320 days.

2. The fact that a large proportion of variables are more or less red also attracted early notice, and led to the belief that some connection existed between color and variability. Mr. Chandler thinks that present knowledge of this relation may be stated as follows: "That those stars whose chemical constitution manifests itself to us by redness of their light are especially inclined to change in brightness." We may go one step further and say, "that the redness of the variable stars is, in general, a function of the lengths of their period of light-variation. The redder the tint the longer the period." If this shall prove true as discoveries go on, a long step will have been taken in finding the causes of stellar variation.

3. The range of variation and the length of the period. This relation is less certain than either of the preceding ones, and the only feature of interest that appears from study so far is that there is a dissimilarity between the variables of short period and those of long period in this particular.

The last point is the length of period compared with irregularities of their periods and of their light-variations. The discussion of this is only begun in this paper. Its full consideration is reserved for awhile, and until certain work now in hand can be completed.

Table of Standard Wave Lengths. The Johns Hopkins University Circular for May, No. 73, is devoted to notes from the physical laboratory. It contains a table of standard wave lengths by Professor Rowland and an interesting article on "The Concave Grating in Theory and Practice," by Joseph S. Ames, with one full page plate. The mathematical part of the article shows the general theory of the

grating, and also the theory of errors in adjustment. In the descriptive part will be found a full reference to the accompanying plate, information concerning proper adjustments, how to use the grating and something of the methods of work with this delicate piece of apparatus. Particular mention is made of the contents of this circular, because not a few of our readers will find in it answers to some of the queries, at least, that have suggested themselves whenever the subject of gratings is under consideration. Few will be able to read the mathematics, most will be profited by the descriptive part, and some may be helped who are trying to use the gratings.

The Williams College Catalogue of North Polar Stars, Right Ascension for 1885.0. This catalogue is the work of Henry Truman Safford, Ph. D., Professor of astronomy at Williams College, Mass. It was made partly for the practical use it might serve, to other astronomers as well as himself, and partly as a beginning of a more extensive list whose observation is in progress. Professor Safford has also desired to strengthen the weak points of all our standard catalogues, viz., the right ascensions of polar stars. To observe these stars well is one of the most difficult tasks in the range of meridian circle work, and which has been neglected chiefly because few modern observers in the possession of precision instruments care to undertake it.

The instrument used is this work is a fine Repsold meridian circle like those at Madison, West Point and Northfield. The aperture of the object-glass is 4½ inches French, the ratio of aperture to focal distance 1:12, and the diameter of the circle 20 inches French, with four micrometers on either side reading to seconds directly.

The mode of making this catalogue has been mainly differential, but in the case of polars, observations were made above and below the pole, because this process eliminates a certain portion of the personality of the standard observers whose catalogues were Professor Safford's guide, and substitutes his own in their stead. If Professor Safford had used zero stars above the pole, for observations above the pole, and observed below the pole in a similar manner, his right ascensions would have been purely differential and the stand-

ard that of Pulcova. This he claims he did not do partly because the close circumpolars were too few, and partly because the proper motions since 1865 are themselves effected with unknown personalities.

The standard catalogue at first adopted was that of Publication 14 of the *Astronomische Gesellschaft*. The errors that were found in this catalogue were due to a lack of knowledge of true proper motion. A list of eleven stars was chosen from this catalogue, all within ten degrees of the pole, for instrumental correction. In the plan of observation, Professor Safford says he avoided the use of Pond's method, which is employed at Greenwich for time stars only, and not for declinations, although Pond at first himself so used it. He thinks that method is now antiquated and that we need, at the present time, to discriminate between known or standard stars and those which are unknown and to be determined. He then points out the errors of the Pond method and says, "I am pretty well convinced that the strict use of a standard catalogue for clock corrections and instrumental zeros, and a careful study of these latter results, will produce more accurate secondary places than any other."

The stars used for clock correction were commonly those of the Berlin Jahrbuch. If the stars were taken from the American ephemeris they were reduced to the Jahrbuch standard by a correction of $-0.016s$ suggested by Professor Auwers. The collimation was at first obtained by the level and the mercurial horizon, afterwards by the collimators. No star was considered as determined on any evening which had been required on the same evening for instrumental corrections.

The observations began in the summer of 1882 and the instrument has not been reversed at all, but Professor Safford proposes to do so soon. He thinks the reversal of the instrument will not much affect the results already obtained because the range of declination is small. The object-glass and eye-piece have been once interchanged, and the more important stars have been observed in both positions. This will diminish pivot errors upon the mean.

Then follows the detailed study of the catalogue which will prove of special interest to those engaged in meridian circle work.

The catalogue proper embraces six tables, the first a list of right ascensions for 1883.0; the second a list of right ascensions for 1884.0; third, mean right ascensions reduced to 1885.0; four and five, observations respectively of 1886 and 1887; and six is the catalogue of 261 stars arranged in the order of right ascension. The first column gives the current number; second, the star's name; third, mean epoch; fourth and fifth, number of observations; sixth, mean right ascension for 1884.0; seventh, precession; eighth, secular variation; ninth, declination for 1885.0; tenth, annual variation in declination.

This catalogue appears to be a piece of very careful and thorough work, as well might be expected from the reputation of its distinguished author.

Death of Dr. Warren De la Rue. We regret to find in the May number of the *Observatory* the following sad notice:

The scientific world has sustained a great loss in the death of Dr. Warren De la Rue, F. R. S., whose energy was only equalled by his generosity. His friends had noticed with regret for some time past that his health was rapidly failing; but he made great efforts to attend the meetings of the Royal Astronomical Society, and at the last Annual General Meeting spoke a few pertinent words on his own subject, photography. He died on Good Friday last, at the age of 74.

South Bergen Observatory. The private Observatory of Henry Harrison is at South Bergen, N. J. Many of our readers will remember the artistic work of Mr. Harrison, named the telescopic picture of the moon, of which we have spoken many times favorably. In a recent private letter he says: "After selling my 4¼-inch telescope of short focus, I mounted one 5¼ inches in aperture of 74 inches focus, with circles respectively 8 and 12 inches in diameter. I have sidereal and mean time clocks, micrometer and spectroscope. My astronomical work is limited, being confined to drawing mainly. I am now at work on a picture of the nebula of Orion." Mr. Harrison speaks of his unfinished work of the series of telescopic moon pictures, the first of which only was published. Some scientific friends have been in conference to ascertain what it would cost to complete the series. It is to be hoped

that the lithographic plates will not be found so expensive as to long delay the completion of this unique, accurate and very useful representation of the moon's surface.

The Jena Glass for Telescopes. From time to time queries have been made concerning the Jena glass, its advantages over common glass and the prospects of its use for telescopes in the future. Until recently little could be said in answer to these queries because the glass was new, having been tested only in a small way by physicists or opticians, so far as we have known. In a paper published by Professor C. S. Hastings, in the June number of the *American Journal of Science and Arts*, entitled "Secondary Chromatic Aberration for a Double Telescope Objective," a description of a telescope sensibly free from this defect is given and the glass used is of the new kind. As to its advantages and the probability that it may be used for telescope objectives something of interest is learned from the paper above referred to, as follows:

"The largest objective which could be made of the pieces in my possession was of 2¾ inches clear aperture. This, though smaller than desired, was sufficient to give a fairly satisfactory answer to the questions. Accordingly the glasses were worked accurately to the curvatures and thicknesses corresponding to the computations and mounted for use. The astonishing beauty of the images in the new telescope was its most surprising feature at first. The familiar purple was wholly wanting, or at least, could only be recognized with the closest attention, with magnifying powers greater than forty to the inch aperture, and on objects most suitable to its exhibiton. But the moment that the instrument was applied to astronomical use it was also evident that its defining power was remarkable. The companions to Polaris and Rigel, instead of being objects which require somewhat careful looking, as is the case with my eye and an ordinary achromatic of the same aperture, were strikingly plain. More difficult, but certainly seen, was the fifth star in ν Orionis. The binary star, γ Orionis, was so well elongated that its position angle was estimated to within 5° of its true value; on the other hand, ξ Ursa Major, which I suppose to have at present a separation of 1″.7, was divided only with difficulty on a fairly good evening though it was supposed that it would be easy. Saturn showed all that I have seen with an admirable telescope of considerably greater aperture, including more than half of Ball's division, the ring C, a single belt and five satellites, though Tethys and Dione have not been seen unless they

had an elongation equal or greater than that of the end of the ring. Rhea has been seen in conjunction. By reference to the records of many observations which have been made with various telescopes the power of the new telescope was estimated as equivalent to a 3½ inch objective of the ordinary construction. The powers used varied from 53 to 265 diameters, with 194 as the most satisfactory for Saturn and for double-stars.

The Trees along the Canals of Mars. A reader of the MESSENGER asks if we will explain for the benefit of novices the following paragraph clipped from the *Chicago Tribune* of date May 22: "Wiggins says his discovery of the recession of the earth from the sun is the greatest discovery of the age. The recession, he says, is proved by what is known as the precession of the equinoxes, which causes the tropical year to be shorter than the sidereal, the latter being the real measure of the earth's increasing orbit. The time, he declares, will come when it will be necessary to carve up the continent by canals such as we see on Mars, and the same is no doubt true of the planets Saturn and Jupiter. Trees will be planted along the canals to produce moisture as they appear to be along the canals of Mars."

Friend Colbert, what is the matter with the *Tribune* editorial staff? They ought every one to be indicted for astronomical heresy. If you do not see to it the reporters of the *Tribune* will next be asking astronomers what kinds of trees Wiggins has planted by the canals of Mars. The worst of it is we imagine how Professor McLeod of Montreal, next town to Wiggins' place, will smile when he sees that Chicago has the news first hand.

Colby's New Physical Laboratory. In a letter bearing the date May 19, from Professor W. A. Rogers, we were delighted to learn that Col. R. C. Shannon, a graduate of Colby University, has contributed the sum of $15,000 for the erection of an Observatory and physical laboratory for the department of physics, which is Professor Rogers' department of work in the University. Professor Rogers says the laboratory will be fully equipped for metrological work, and that soon he will order $3,000 worth of apparatus for this special line of work.

Photographic Chart of the Sky. The third number of the Bulletin of the Permanent International Committee on the photographic chart of the sky has just been received. It contains an introductory note by the president of the committee, Admiral Mouchez, referring to the coming reunion of the committee at Paris, Sept. 15, 1889; a Description of an Instrument and Explanation of a Method of measuring the positions and magnitudes of stars photographed and of engraving them upon metallic plates, by Mr. Isaac Roberts; Measures of Plates according to the method of rectangular coördinates, by H. G. van de Sande Bakhuyzen; communications relative to the dimensions of the reticules to be used for the measurement of plates, by Drs. H. C. Vogel and D. Gill, and the correspondence between several members of the committee. The paper by Mr. Roberts appeared in the November number of the *Monthly Notices* of the R. A. S. and is illustrated by actual specimens of measurement and engraving, which appear to be very satisfactory.

Professor van de Sande Bakhuyzen also gives the results of actual measurement of a photographic plate taken by the Henrys, Aug. 5, 1887, and a comparison of these results with the Leyden meridian circle observations of the same region of sky. The portion of the plate exposed was about 6 in. or 2° in diameter and contained 341 measurable stars. The comparison with the meridian observations shows that the relative positions obtained by photography are at least equal in accuracy to those obtained with the best meridian circles.

In the correspondence Mr. Gill suggests the following as the most important points to be decided upon by the Congress in 1889:

1. Assignment of region of sky to be photographed at different observatories.

2. What time shall be allowed each observatory in which to complete the work? In case any observatory fails to perform the amount of work assigned to it shall the Bureau confide this work to another more active observatory?

3. Annual reports will be required of each observatory. These reports will be addressed to the president and published in the Bulletin.

4. What kind of plates shall be adopted? Shall the

plates be furnished by the same laboratory and verified by the same person, appointed by the Bureau?

5. What are the best methods by which to photograph, as far as possible, all the stars to the 14th and 11th magnitudes on the two series of plates? How shall we decide that the plates contain quite all the stars in question?

Professor C. Piazzi Smyth of Clova, Ripon, England, has again favored us with one of those genial letters which occasionally it is our good fortune to receive. In the midst of unfavoring circumstances, so far as externals are concerned, we can still read between the lines the fervor of a hope in usefulness that nothing mortal can quench or disarm. What matters it though the years be three-score and ten, the light of a soul true and good burns on, and the glorious stars keep their courses, and will, till the better hope be ushered in.

Dr. Copeland has removed to Edinburgh. His address will be Royal Observatory, or 15 Royal Terrace, Edinburgh, Scotland. We are informed that the Dun-Echt circulars will be continued from Lord Crawford's Observatory as heretofore.

Latitude of Detroit Observatory. We have received a paper by Ludoic Estes, Ph. D., formerly of the University of Michigan, now at the University of North Dakota, Grand Forks, which contains a full discussion of the latitude of the Detroit Observatory, Ann Arbor, Michigan. The instrument used was a 3-inch transit instrument, made by Messrs. Fauth & Co. of Washington, D. C., of which a particular description is given. After finding the value of a revolution of the micrometer screw, the value of one division of the zenith level, and a table of needed star places, the observations and reductions of 138 pairs of stars are given in tabular form for the determination of the latitude sought. The discussion of the results appears in full and shows a good degree of precision in detail. The final result obtained for the latitude of the Observatory at Ann Arbor is 42° 16′ 47″.87. That which has been in use by the American Ephemeris is 42° 16′48″.00, a difference of 0.13″ of a second of arc. Mr. Estes' work is published in neat form.

XIIM

Errata. In the April issue, page 168, 12th line from top, the word "light" should be "chromosphere." On page 169, 7th line from top, the word "southward" should be "outward." On the same page, 9th line from bottom, the word "photosphere" should be "chromosphere." Page 184, last line, for "photosphere," read "chromosphere."

In the May issue, page 228, 10th line from bottom, "Batche" should read "Bache." Page 231, first line, "occultation" should read "osculation." On the same page, 9th line from bottom, "Brighton" should be "Bridgeton."

BOOK NOTICES.

Elements of Geometry. A New System of Presentation; by C. F. R. Bellows, M. A., C. E., Professor of Mathematics, Michigan State Normal School, and Author of Several Text-Books on Mathematics. Philadelphia: Messrs. John E. Potter and Company, Publishers, 29 to 35 North Tenth Street; pp. 374.

The author of this new book calls the attention of the teacher, in the outset, to geometry as an educational instrument, adapted

1. To train the hand and the eye;
2. To train the attention and concentrate the mind;
3. Te develop the imagination and conceptive power;
4. To cultivate the language, and
5. To develop and train the logical powers.

These are evidently the ideas of a teacher of large experience and mature judgment in the available uses of geometry as a means of cultivating and strengthening the mental powers, and of one who believes that "it is what a student does for himself, not what is done for him, that *educates* him." With these principles in mind, particular attention will be given to the choice and arrangement of the subject matter of the text-book to be used. In this geometry the classification of its themes finds logical sequence in the order of the properties, relations and measurement of geometrical figures. The old method of dividing the work into books, instead of into chapters and sections, is followed, contrary to the practice of the best late writers. While not a serious defect, this plan seems to us to disturb the unity and the continuity of the theme, which is so well modernized in other essential particulars.

The books are ten in number, treating respectively of the following topics: 1, lines, angles, polygons; 2, proportion,

similarity; 3, the circle; 4, rectangles on lines; 5, supplementary subjects; 6, points, lines and planes; 7, polyedral angles; 8, polyedrons; 9, the three round bodies; 10, spherical angles and polygons.

In the details of the plan careful attention is given to definitions and illustration, so that the student is early made acquainted with, and is exercised in, the easy and exact language of geometry, which is the first essential in strong argument. The book differs from others in the mode of its proofs of theorems. Instead of giving a demonstration complete as is ordinarily done, the proposition is stated, mode of constructing the figure and of making the special enunciation are shown, and then something of an outline of the proof given, leaving the student something to do to complete the demonstration and draw the proper conclusion. This exercises the reasoning powers constantly and necessarily without making the work of proofs an effort of mem ory on the part of the student, which is too often the case when the full demonstrations are given. Then, to be sure that the student understands what he is doing, questions, unsolved examples and bare theorems are freely used throughout the work in keeping with its general plan as before suggested. By the aid of such a book on geometry as this a student ought to be able to get an excellent knowledge of the subject in the time usually allotted to its study. The publishers have put this book in a very neat dress, indeed quite as novel as the work of its author inside.

Algebraic Analysis, Solutions and Exercises Illustrating the Fundamental Theorems, and the Most Important Processes of Pure Algebra; by G. A. Wentworth, A. M., Professor of Mathematics in Phillips Exeter Academy, J. A. McLellan, LL. D., Inspector of Normal Schools, and Conductor of Teachers' Institutes, Ontario, Canada, and J. C. Glashan, Inspector of Public Schools, Ottawa, Canada. Part 1. Boston, U. S. A.: Messrs. Ginn & Company, Publishers, 1889; pp. 418.

This is a book intended for teachers or students in algebra who wish to supplement the ordinary text-books for fuller knowledge of, or as specialists in, this interesting branch of mathematics. In the first part the following themes appear: Substitution, principle of symmetry, factoring, measures and multiples, linear equations of one unknown quantity, simultaneous linear equations, quadratic equations, indices and surds, cubic and quartic equations and

determinants. The method of treating a topic is to give a large number of solutions typical in character, then a great number of exercises to bring out methods and principles that are new as well as those known to elementary algebra; in this way the work serves as a guide-book, or a work of reference. As an illustration, let us take the theme of factoring and briefly indicate how the authors have treated it. The first point is the direct application of the fundamental formulæ:

$$(x \pm y)^2 = x^2 \pm 2xy + y^2.$$

Following this is the statement, in ordinary language, of the meaning of the above formulæ. Four typical examples solved, show their application to algebraic expressions of quite varied form of which the third is a fair example:

$$(a-b)^2 + (b-c)^2 + 2\,(a-b)\,(b-c) =$$
$$(a-b+b-c)\,(a-b+b-c) = (a-c)\,(a-c)$$

Remarks pointing out the facts pertaining to the signs of the monomial terms of the expressions are next given, followed by nearly a page of exercises involving numerical and literal exponents. The formula for the difference of the squares of two quantities is next treated in a way entirely similar to those just given. The method of resolving a trinomial with one perfect square term into two binomial factors is fully treated and covers eight consecutive pages. Then follow twelve pages devoted to an extended application of these general formulæ, consisting of groups of exercises, amounting in all to nearly one hundred separate examples to factor, in the application of principles and suggestions accompanying the exercises. Factoring by parts and the application of the theory of divisors are the last points under this general head of factoring, and their development covers thirty pages of well selected matter, giving the themes a fullness and generality of treatment that is unusually exhaustive.

We were also interested in reading the topics entitled cubic and quartic equations and that of determinants. It would seem to us, after years of experience in teaching, that those who intend to teach or study algebra in an exact and comprehensive way would do well to give this important work a careful examination. It is especially commended to all who are fond of algebraic analysis.

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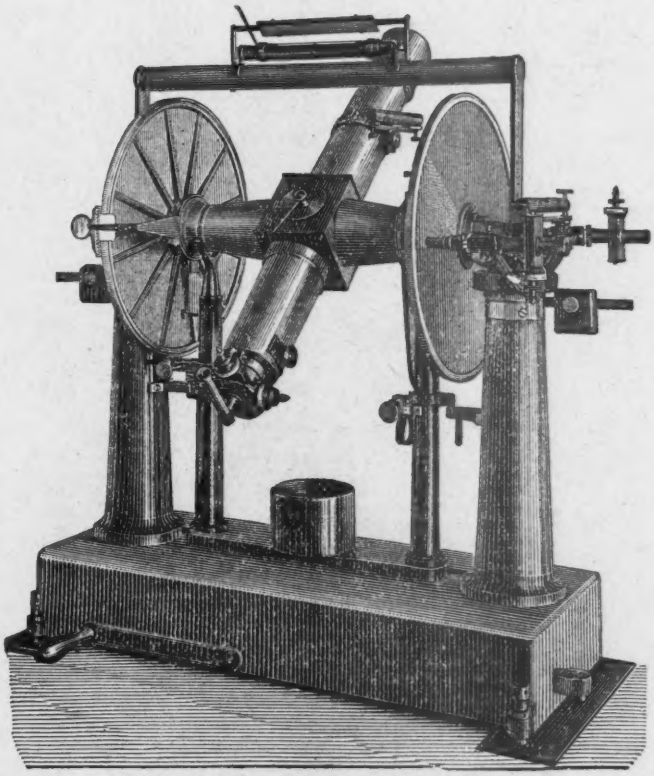

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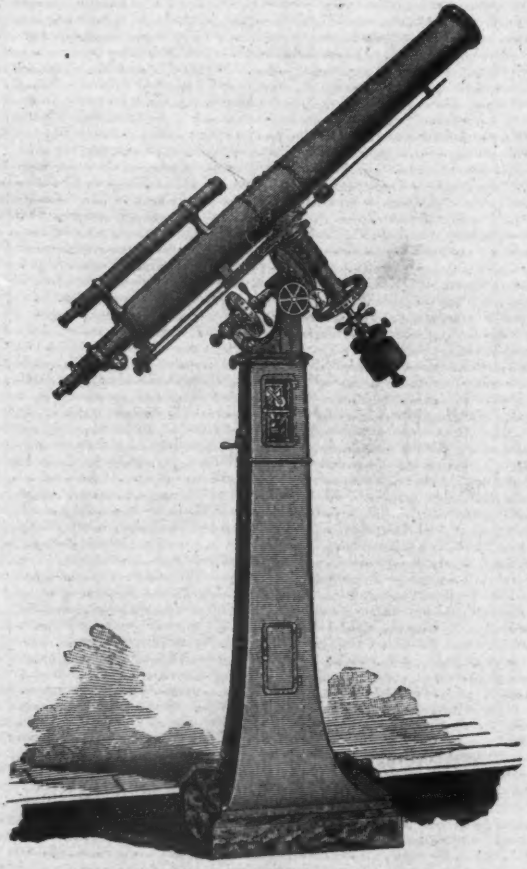

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